LeCroy 9310 series

Digital Oscilloscopes

Basic Performance Test Procedure

Version 1.1

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SECTION 1 PERFORMANCE VERIFICATION

1.1 Turn On

Switch on the power using the power switch on the rear panel.

Check:
- That the display turns on after about 10 seconds.
- That the display is stable.
- That the range of intensity and grid intensity is reasonable.

Wait for about 10 minutes for the scope to reach a stable operating temperature.

1.2 Noise on the Inputs

This is to verify the proper operation of the main board (front end, ADC's, TDC).

1.2.1 Channel 1 and Channel 2; 1 MOhm DC

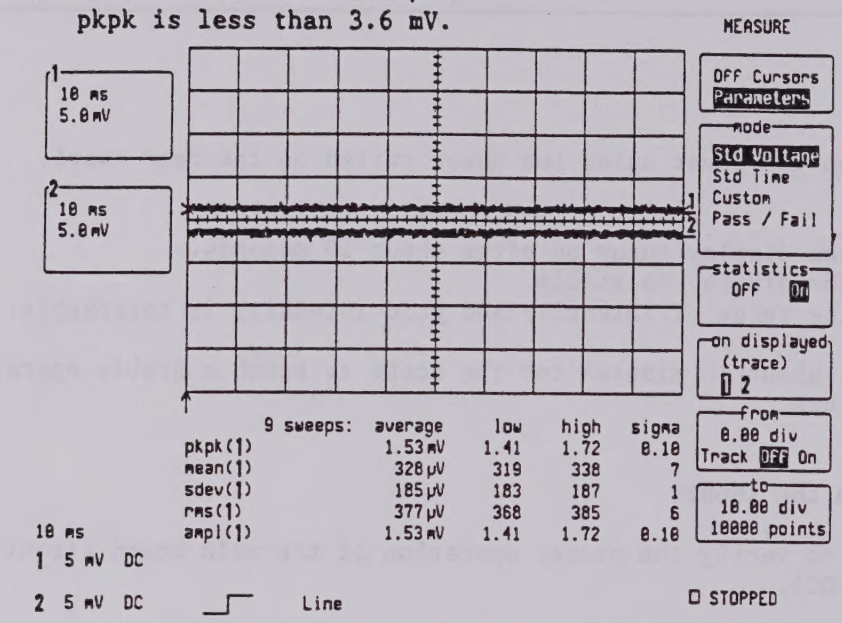
With no signal connected to the inputs, set up the DSO as follows:

- Turn on traces CH1 and CH2.
- Single grid.
- Input coupling: CH1 and CH2 1 MOhm DC.
- Input gain : 5 mV/div.
- Trigger:
  - Smart trigger : OFF
  - Source : Line
  - Coupling : AC
  - Mode : Norm
- Time/div : 10 msec/div
- BWL : OFF
- Turn parameters : ON
- Set mode : STD voltage
- Statistics : ON
- On displayed trace: 1

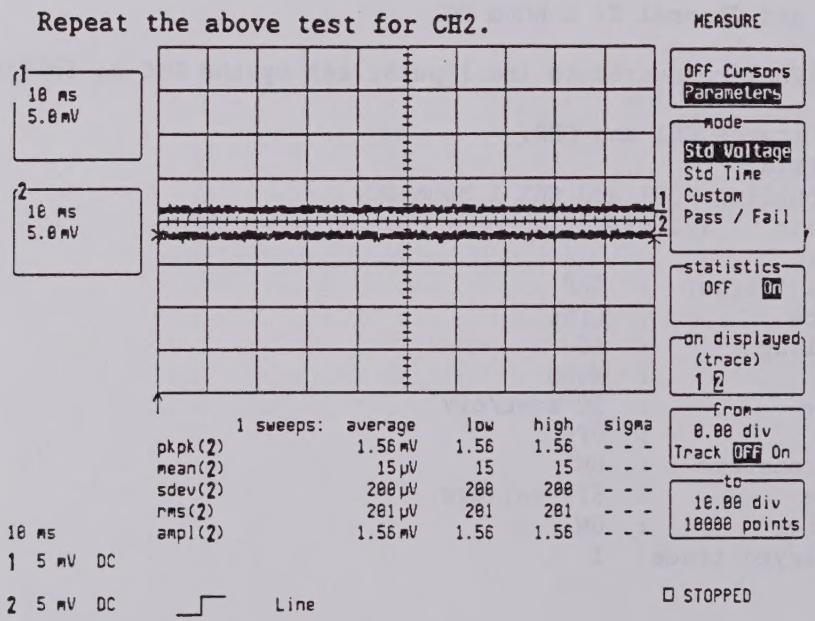
Check:

sdev is less than 360 µV.

pkpk is less than 3.6 mV.



Repeat the above test for CH2.



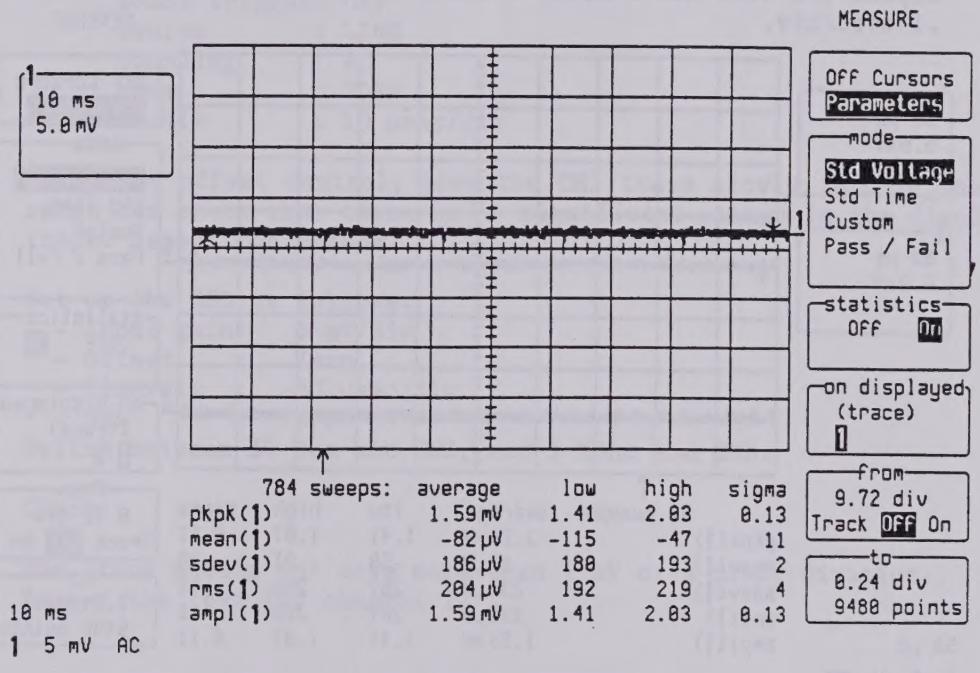
Repeat the test for Time/div = 5 msec/div, 2 msec/div, 1 msec/div, .5 msec/div and check as above.

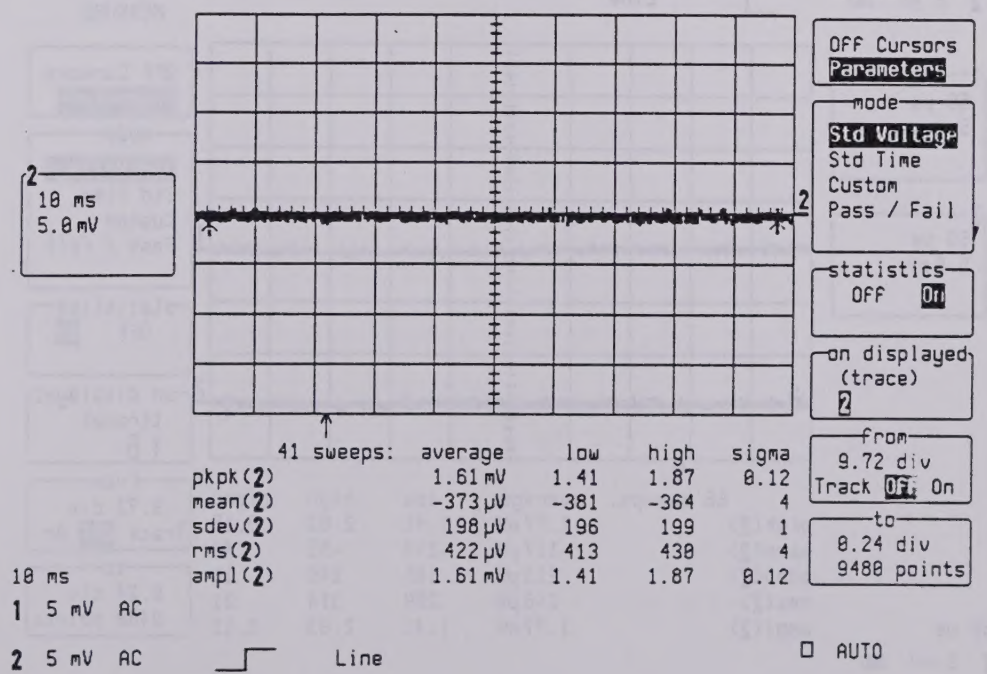
1.2.2 Channel 1 and Channel 2, 1 MOhm AC

- Set CH1 and CH2 input coupling to 1 MOhm AC.

Check for both CH1 and CH2:
  sdev < 360 µV.
  pkpk < 3.6 mV.

Repeat the test for 5 msec, 2 msec, 1 msec and .5 msec/div.



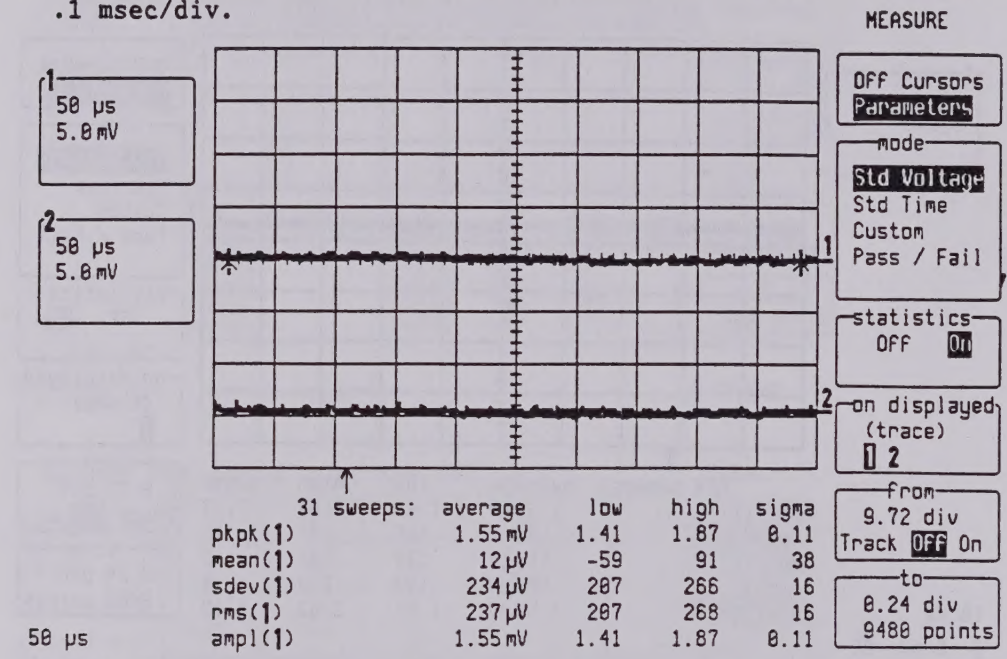


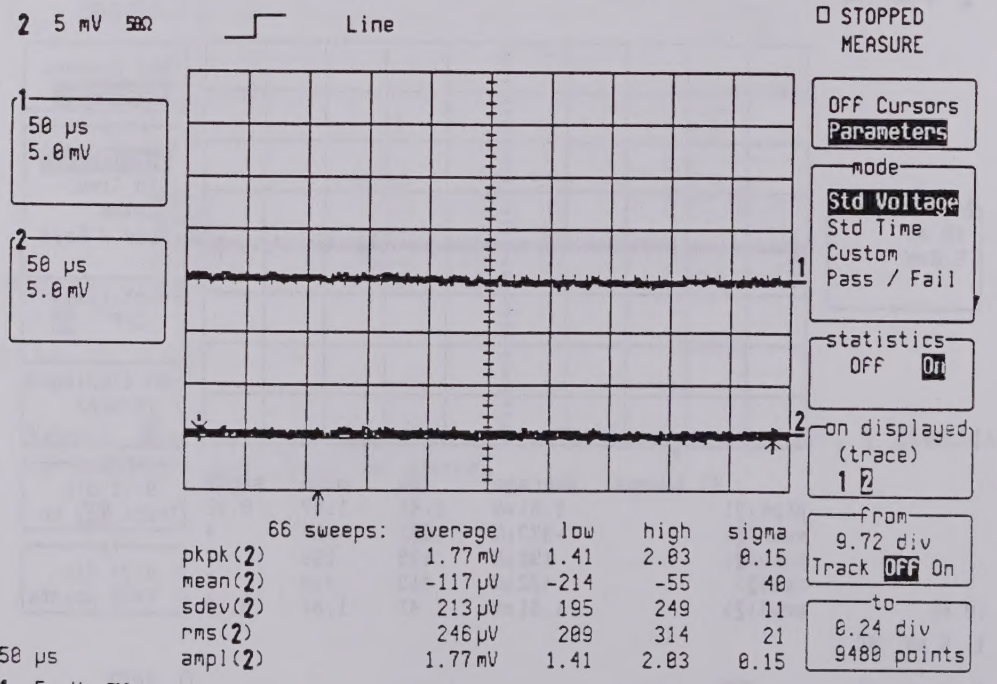
1.2.3 Channel 1 and CHannel 2, 50 Ohm DC

Set input coupling to 50 Ohm DC.
Check for both CH1 and CH2:

sdev < 360 µV
pkpk < 3.6 mV

Repeat the test for 5 msec, 2 msec, 1 msec, .5 msec, .2 msec, .1 msec/div.





1.3 Channel 1 and Channel 2 Offset

Set up the DSO as follows:
- Both CH1 and CH2 inputs open.
- Turn on traces: CH1 and CH2.
- Grid : Single.
- Input coupling: CH1 and CH2: 1 MOhm DC.
- Input gain : 50 mV/div.
- Trigger:
  - SMART Trigger: OFF
  - Source : LINE
  - Coupling : AC
  - Mode : NORM
- Time/div : 10 µsec/div

Using the offset control, move the CH1 trace slowly through the entire range and check that there is no significant change in the displayed trace. Repeat for channel 2.

Set up the DSO as follows:
- Input gain: 5 mV/div
- Offset : Zero
- Time/div : 50 µsec/div
- BWL : OFF

Switch between 50 Ohm and GND, and 1 MOhm and GND.

Check:

The trace should not move more than 1 mV or a minor division.
Repeat the test for channel 2.

1.4 Input Impedance

The input impedance should be 50 Ohm +/- 1% and 1 MOhm +/- 1%. See Front end Calibration procedure, for further detail.

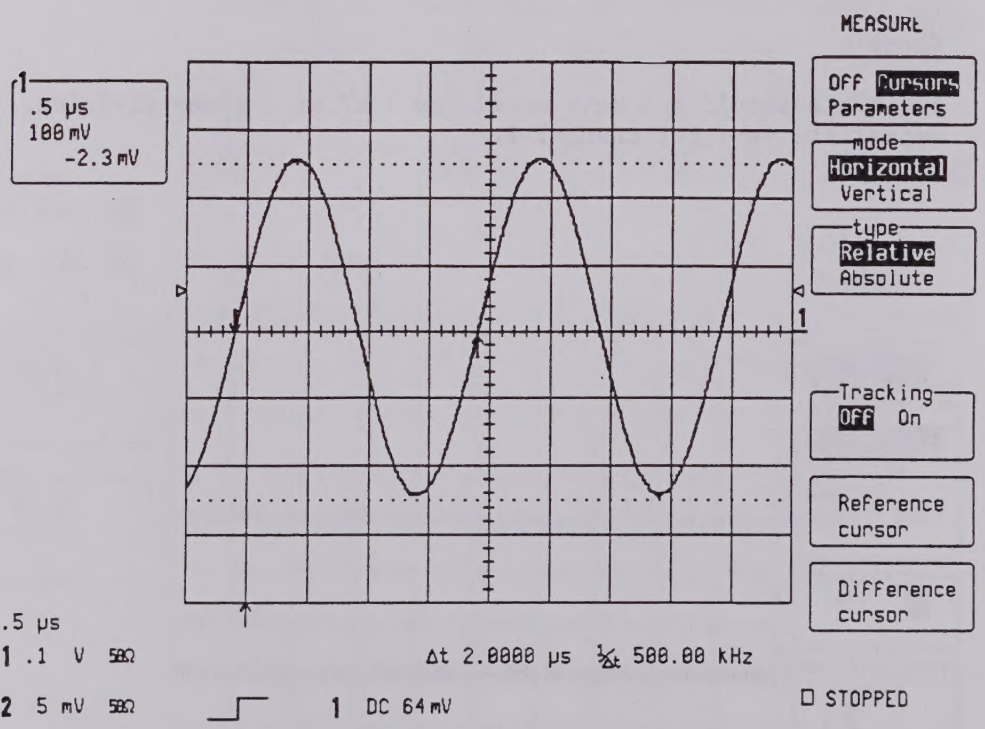
1.5 Bandwidth at 50 Ohm input impedance

The purpose of this test is to ensure that the entire 9310 system has a bandwidth of at least 300 MHz at 50 Ohm input impedance.

Set up a leveled sine wave generator (for example Marconi 2019A):
- Frequency .5 MHz

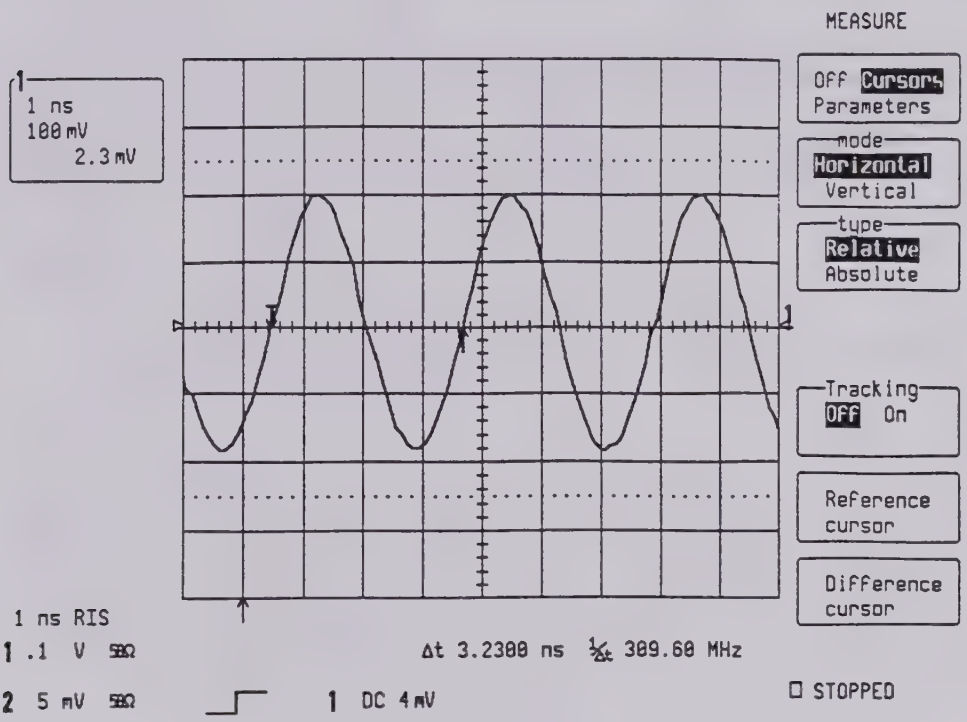
Connect the generator output to CH1 input.
Set input coupling: 50 Ohm
Gain : 0.1 V/div
Time/div : 0.5 µsec/div
Trigger source : CH1, DC, POS, NORM
BWL : OFF

Adjust the generator output amplitude and CH1 offset to get a 5 divisions peak to peak sine wave.

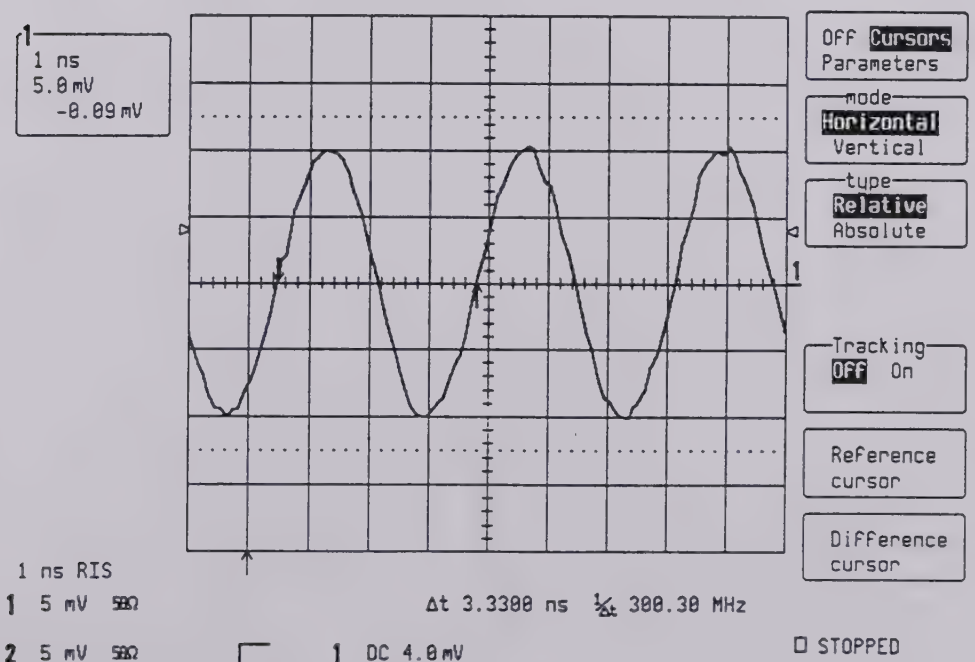


Increase the generator frequency, while decreasing the time/div until the sine wave peak to peak amplitude is .7 x 5 divisions = 3.5 divisions (3dB point) or 70% of the initial amplitude at .5 MHz.

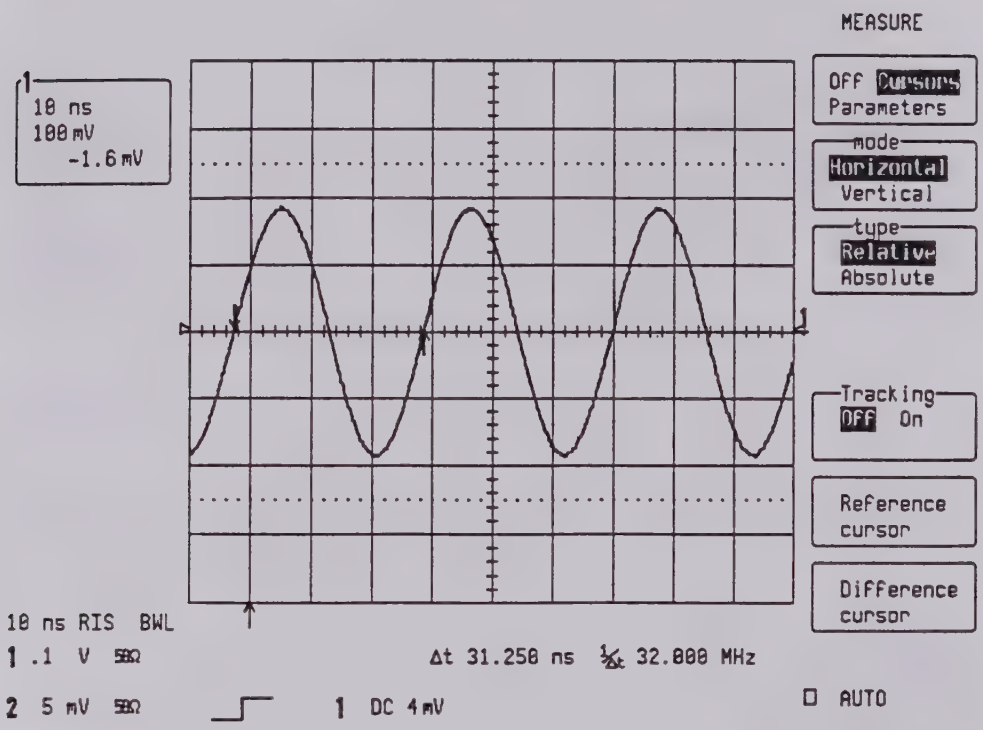
Check:
- The frequency of the generator must be at least 300 MHz.



Repeat the above test for input volts/div = 50 mV, 20 mV, 10 mV. Check at 5 mV/div that the bandwidth is at least 270 MHz.



Set the bandwidth limiter on. Check that the frequency of the generator at the 3dB point is between 22 MHz and 43 MHz.



Repeat all the tests for channel 2.

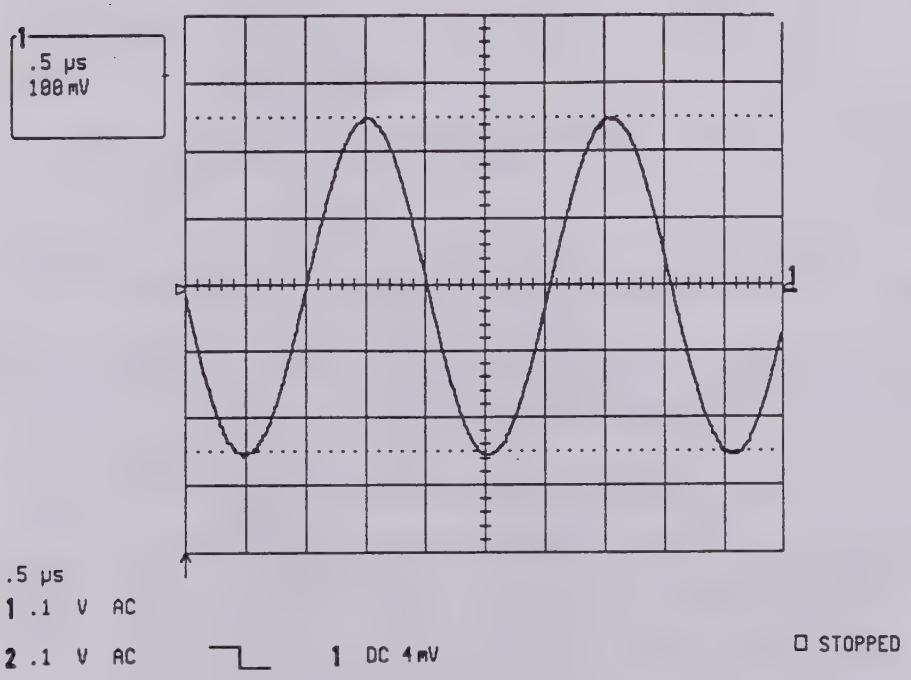
1.6 Bandwidth at 1 MOhm Input Impedance

The purpose of this test is to ensure that the entire 9310 system has a bandwidth of at least 250 MHz at probe tip.
Set up a Tektronix SG503 leveled sine wave generator or equivalent.

- Frequency .5 MHz
- Amplitude 5V peak to peak

Terminate the output of the SG503 via a 50 Ohm feedthrough and connect it to the channel 1 input through a 10X-probe using the probe tip BNC Jack adapter.
Make sure the probe tip is perfectly adjusted, low frequency and high frequency (see brochure enclosed with probe).

- Set input coupling: 1 MOhm/AC
- Gain: .1 V/div
- Time/div: .5 µs
- Trigger source: CH1, DC, POS, NORM
- BWL: OFF
- Set the SG503 output amplitude and the CH1 offset to provide a 5 divisions peak to peak sine wave.

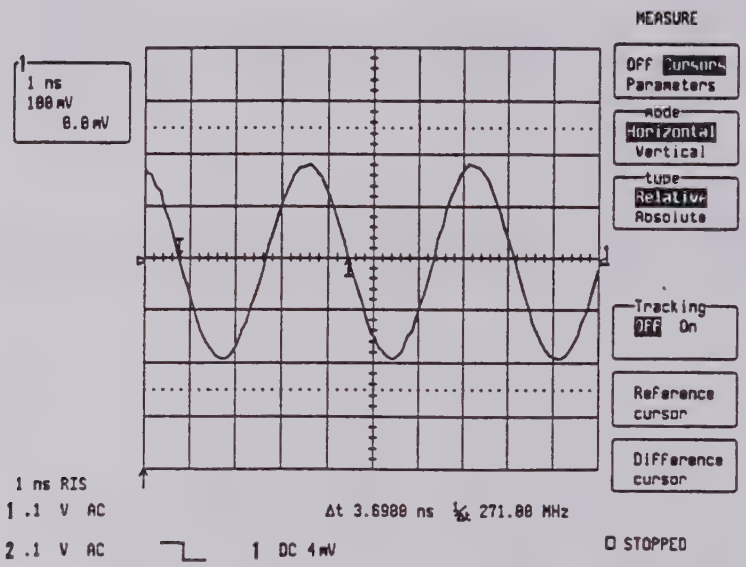


Increase the SG503 frequency, while decreasing the time/div until the sine wave peak to peak amplitude is:

.7 x 5 divisions = 3.5 divisions (3 dB point)

Check:

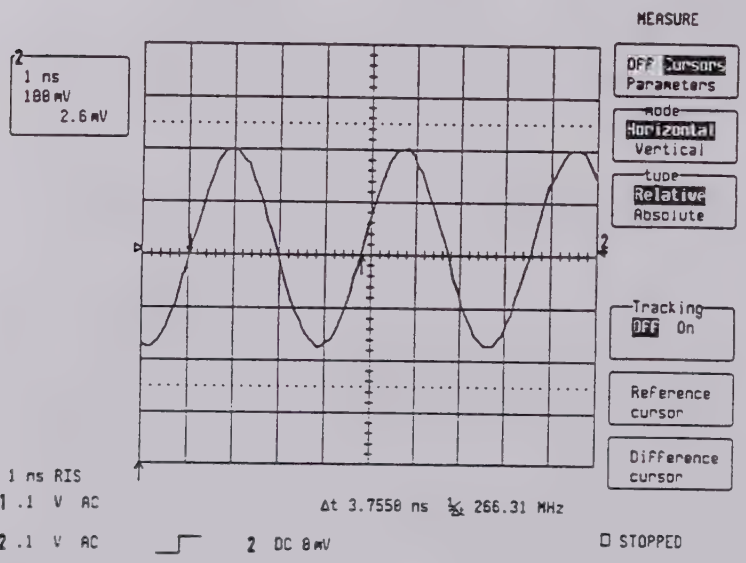
- The frequency of the SG503 must be at least 250 MHz.



Repeat the above test for input volts/div = 50 mV, 20 mV, 10 mV, and 5 mV.

Set the bandwidth limiter on, and check that the frequency at the 3 dB point is between 22 MHz and 43 MHz.

Repeat all the tests for channel 2.



1.7 Manual Linearity Test using an External High Precision Voltage Source (NIST Traceable)

In the absence of the Computer Automated Calibration System based on LeCalsoft for the 9310 oscilloscope, the manual Performance Test Procedure can be followed to establish a NIST traceable calibration, provided the measurement instruments used are NIST traceable calibrated.
For a NIST calibration, follow the manual linearity test procedure using a calibrated and certified high precision (better than 0.1%) voltage source, for example TEK PS5004 supported by LeCalsoft.

Manual linearity test procedure

Set scope to:

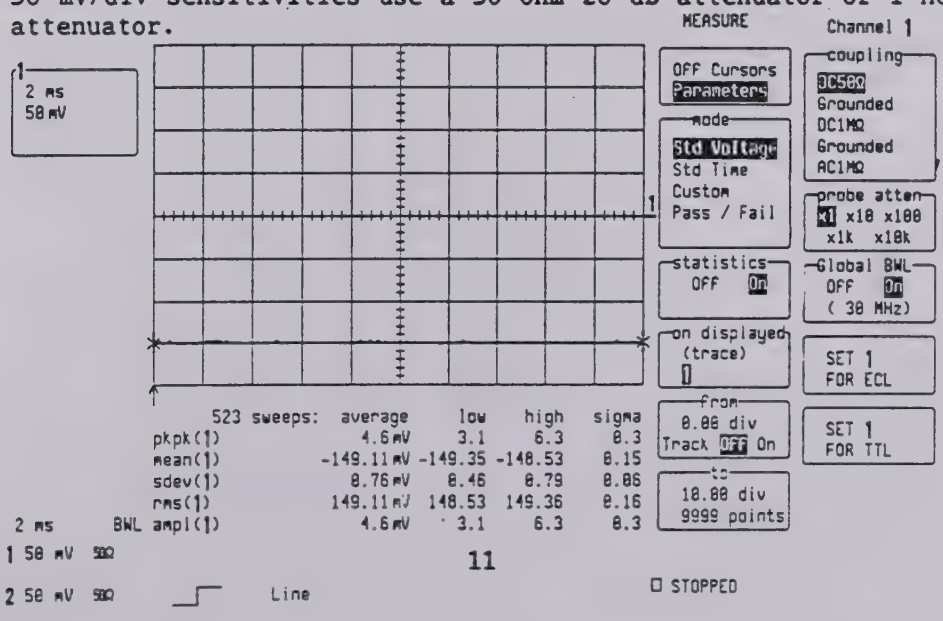
Single grid ON.
Channel to be tested ON.
Offset : 0 mV
Time/div : 2 msec
BWL : ON
Trigger : Line
Smart trigger: OFF
Parameters : Turn ON.
Mode : Std voltage

For each V/div and both 50 Ohm and 1 MOhm DC coupling and for all channels separately, check the following:

From the high precision voltage source, apply the following 3 voltage values, one after another, to the channel to be tested:

0
+ 3 major screen divisions
- 3 major screen divisions.

For each point, read off the 'Mean' parameter voltage and compare to the digital read-out of the voltage reference. The difference of the two values in volts should be within 2%, 3% or 5% of full scale of the scope depending of the sensitivity. For 2 mV, 5 mV, 10 mV, 20 mV and 50 mV/div sensitivities use a 50 Ohm 20 dB attenuator or 1 MOhm 20 dB attenuator.



Range	50Ω Test	1MΩ Test	Test of Conditions			Limit	Reading Mean parameter	
Volt/div	20 dB attenuator	20 dB attenuator	Power supply output	Scope input	Scope full scale	Tolerance % of full scale	Min value	Max value
2 mV	YES	YES	± 60 mV	± 6 mV	± 16 mV	± 5%	± 5.2 mV	± 6.8 mV
5 mV	YES	YES	± 150 mV	± 15 mV	± 40 mV	± 3%	± 13.8 mV	± 16.2 mV
10 mV	YES	YES	± 300 mV	± 30 mV	± 80 mV	± 2%	± 28.4 mV	± 31.6 mV
20 mV	YES	YES	± 600 mV	± 60 mV	± 160 mV	± 2%	± 56.8 mV	± 63.2 mV
50 mV	YES	YES	± 1.5 V	± 150 mV	± 400 mV	± 2%	± 142 mV	± 158 mV
.1 V	NO	NO	± 300 mV	± 300 mV	± 800 mV	± 2%	± 284 mV	± 316 mV
.2 V	NO	NO	± 600 mV	± 600 mV	± 1.6 V	± 2%	± 568 mV	± 632 mV
.5 V	NO	NO	± 1.5 V	± 1.5 V	± 4 V	± 2%	± 1.42 V	± 1.58 V
1 V	NO	NO	± 3 V	± 3 V	± 8 V	± 2%	± 2.84 V	± 3.16 V

1.8 Trigger Level

Set up any sine wave generator, capable of generating sine waves to 500 Hz, for example Intron IFG-422 or Topward TFG-8101:
- Frequency 500 Hz.

Connect the output of the generator to channel 1.
Set up the DSO:

Turn OFF all the traces except CH1.
Set the trigger:

Smart trigger	:	OFF
Source	:	CH1
Coupl	:	DC
Mode	:	NORM
Delay	:	50% Pretrigger
Level	:	Zero

Set the input CH1:

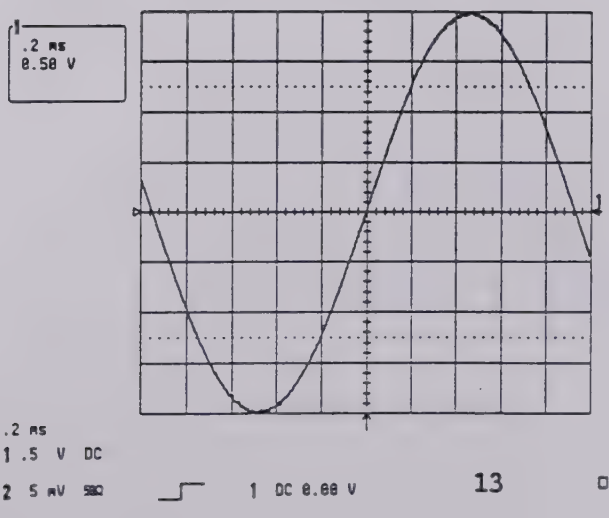
Coupl	:	1 MOhm, DC
Gain	:	.5 V/div
Var	:	Gain 1
Offset	:	Zero

Set the time base:

Time/div: .2 msec/div

Adjust the sine wave generator's output amplitude to get 8 divisions p-p, corresponding to a 2 V amplitude. It is important that the offset of the input is set to zero (use panel status to verify). Use the offset adjustment of the sine wave generator to center the signal with respect to the screen. Later, the test on the EXT trigger level requires that the signal has an absolute range of ± 2 V.

Check:
- The sine wave must pass through the horizontal center of the screen (50% Pretrigger line) at the vertical position zero (vertical center) within ± 2 minor divisions.

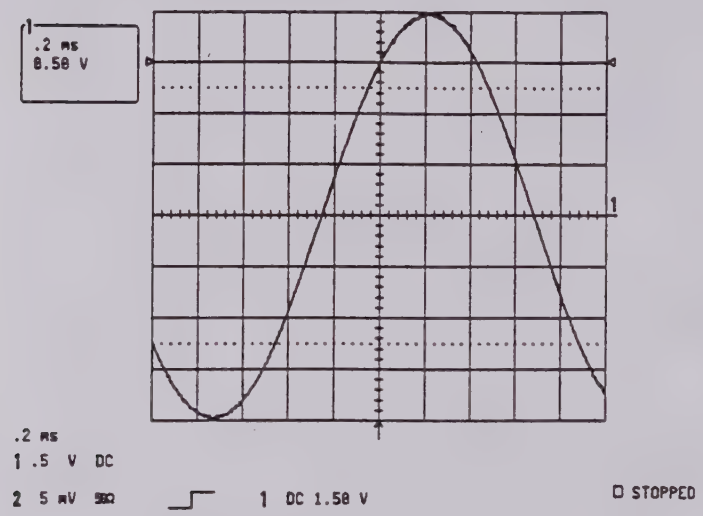


Repeat for the following conditions:

- Trigger slope POS and NEG (verify slope at check point)
- Trigger coupling DC, AC HFRej

Set the trigger level to + 1.5 V (show status).

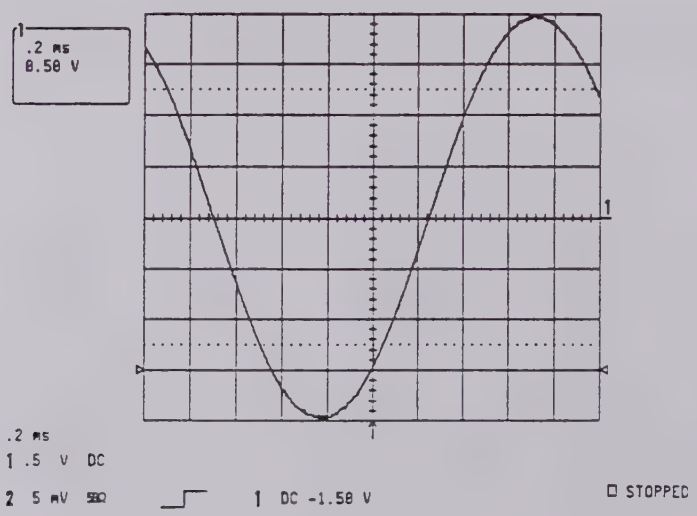
Check:
- The sine wave must pass the horizontal center at + 3 divisions within ± 2 minor divisions.



Repeat for the following conditions:

- Trigger slope POS and NEG (verify slope at check point)
- Trigger coupling DC, AC, and HFRej

Set the trigger level to - 1.5 V.



Check:
- The sine wave must pass the horizontal center at - 3 divisions within ± 2 minor divisions.

Repeat for the following conditions:

- Trigger slope POS and NEG (verify slope at check point)
- Trigger coupling DC, AC, and HFRej

Disconnect the input from CH1 and connect it to CH2.

Turn off all the traces except for CH2.

Set input CH2:

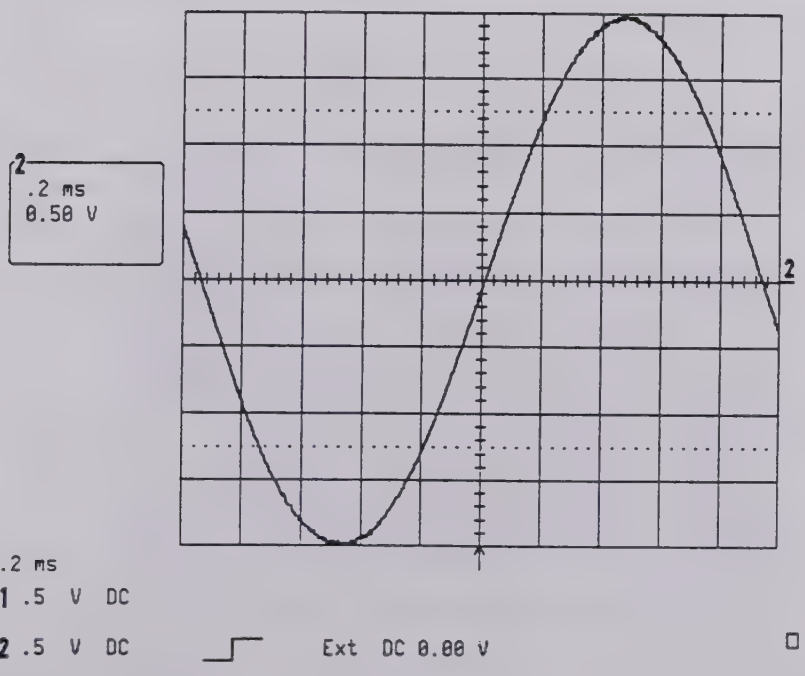
- Coupl : 1 MOhm, DC
- Gain : .5 V/div
- Var : Gain 1
- Offset: Zero

Set the trigger source to CH2.

Repeat the above check procedure for CH2.
Connect the output of the generator to EXT input and to CH2 via a coaxial T-connector. The cable length from EXT to CH2 must be short, at most 2 nsec.

Set trigger source to EXT.

Repeat the above check procedure for EXT trigger, but observing the effect on channel 2.
The tolerance for the level crossing is ± 2 minor divisions for the EXT trigger level.



1.9 Bandwidth for EXT Trigger

Set up a sine wave generator (for example Marconi 2019A):

- Frequency 300 MHz
- Amplitude 2.8 V p-p (maximum for Marconi)

Connect the output of the generator to EXT input and to CH2 using a coaxial T-connector. The cable length between EXT and CH2 must be short (at most 2 nsec).

Set up the DSO:

Turn off all the traces, except CH2.
Set the trigger :

SMART trigger: OFF
Source : EXT
Coupl : DC
Mode : NORM
Delay : 50%
Level : Zero

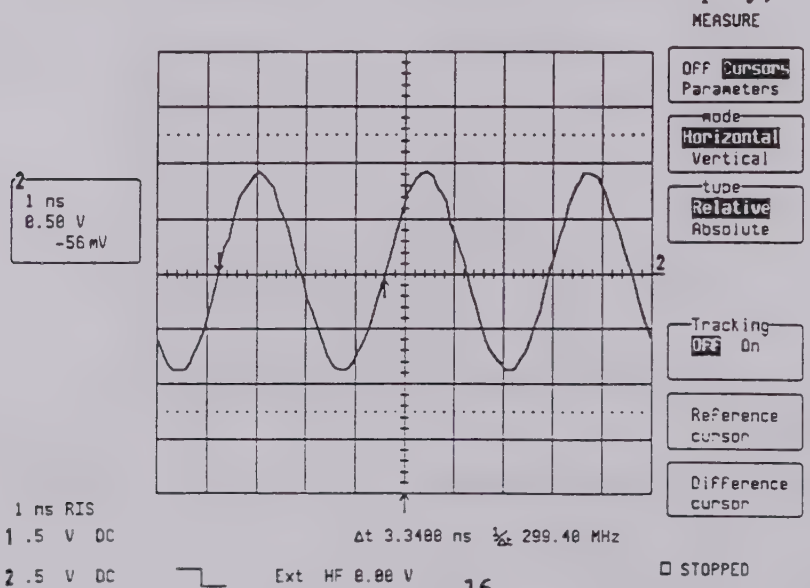
Set input CH2:

Coupl : 50 Ohm
Gain : .5 V/div
Var : Gain 1
Offset: Zero

Set time base:

Time/div: 1 nsec/div
RIS : ON

Check:
- The scope must keep triggering in a stable way (i.e., a smooth 300 MHz sine wave must be visible on the display).



1.10 Smart Trigger

1.10.1 Trigger on Pulse Width >, <

Set up the DSO:

Turn off all the traces except CH1.

Set the trigger:

```
Smart trigger: ON
Trigger type : Glitch
Source       : CH1
Coupl        : AC
Slope        : +
Level        : Zero
Delay        : 0% Pretrigger
```

Set the input of CH1:

```
Coupl : 50 Ohm
Gain  : .5 V/div
Var   : Gain 1
Offset: Zero
```

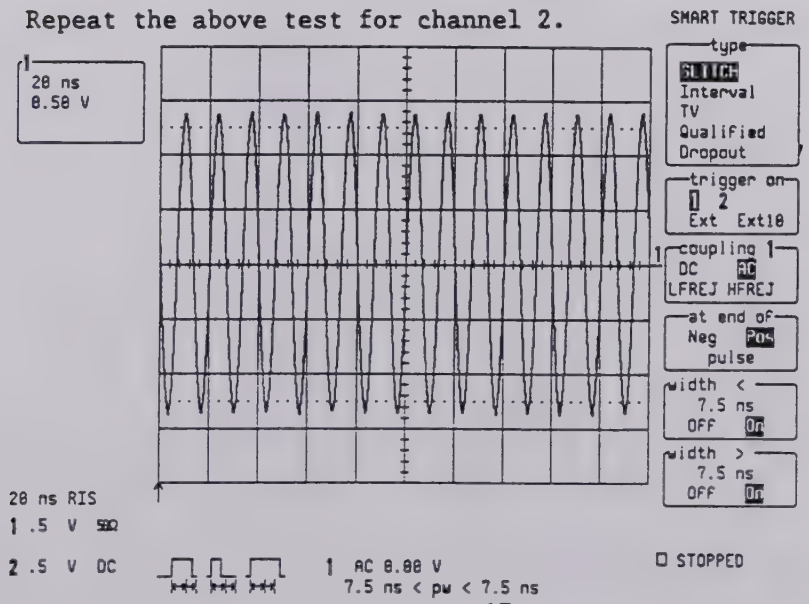
Set the time base:

```
Time/div: 20 nsec/div
RIS     : ON
```

Apply a sine wave signal of 2.8 V p-p at 75 MHz. Adjust pulse width to 7.5 nsec for both < and >, and switch between width < and width >.

Check:
- Width < 7.5 nsec scope should trigger
- Width > 7.5 nsec scope should not trigger

Repeat the above test for channel 2.



1.10.2 Trigger on Interval Width >, <

Set up the DSO:

Turn off all the traces except CH1.

Set the trigger:

```
Smart trigger: ON
Trigger type : Single source
Width type   : Interval width
Source       : CH1
Coupl        : AC
Slope        : +
Level        : Zero
```

Set the input of CH1:

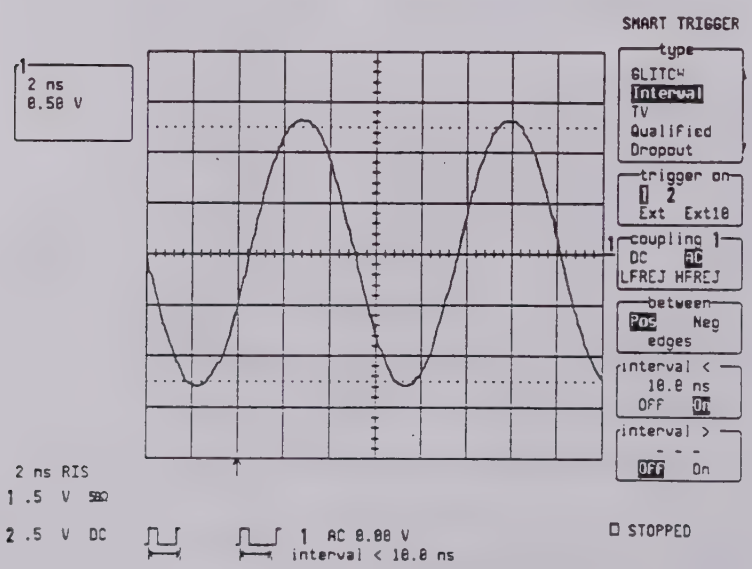
```
Coupl : 50 Ohm
Gain  : .5 V/div
Var   : Gain 1
Offset: Zero
```

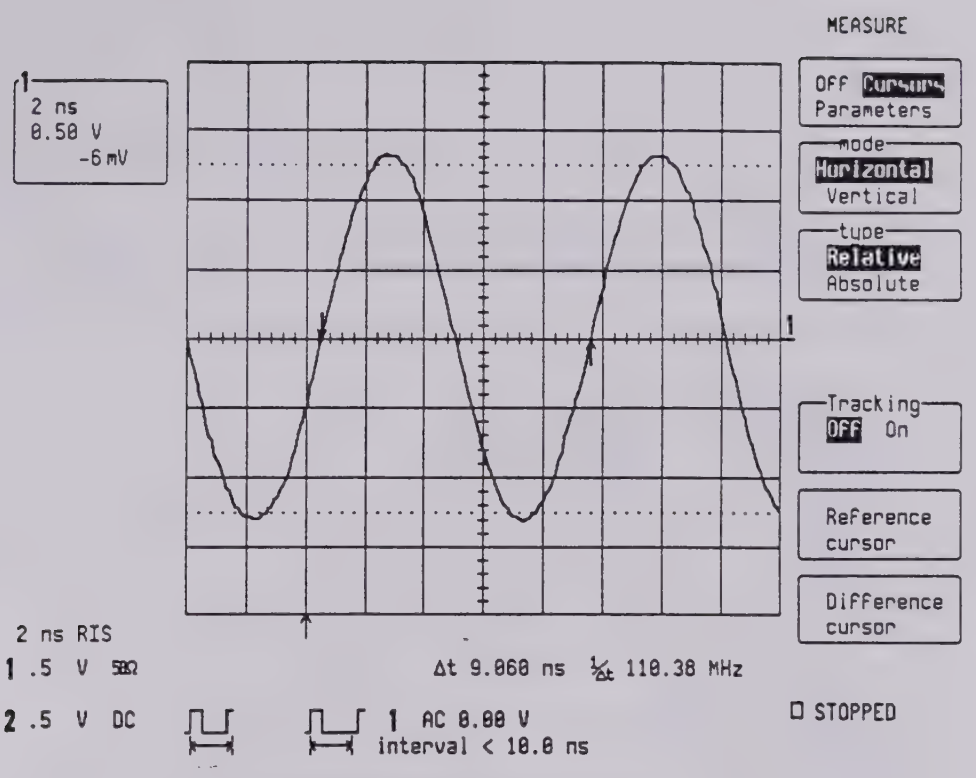
Set the time base:

```
Time/div: 2 nsec/div
RIS     : ON
```

Apply a sine wave signal of 2.8 V p-p at 200 MHz to CH1. Turn to interval width < and adjust width to 10 nsec.

Check:
- 200 MHz: Width < 10 nsec, scope should trigger
- 110 MHz: Width < 10 nsec, scope should trigger
- 91 MHz : Width < 10 nsec, scope should NOT trigger

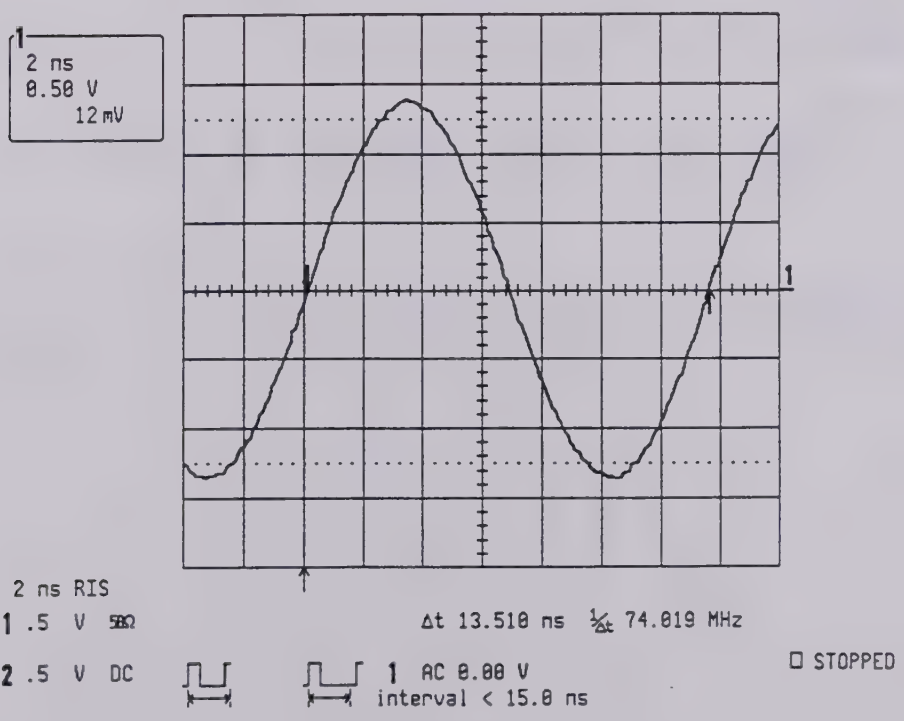




Set frequency to 74 MHz and interval width to < 15 nsec.

Check:

- 74 MHz: Width < 15 nsec, scope should trigger
- 61 MHz: Width < 15 nsec, scope should NOT trigger



Set up the DSO:

Turn off all the traces except CH1.

Set the trigger:

```
Smart trigger: ON
Trigger type : Single source
Width type   : Interval width
Source       : CH1
Coupl        : AC
Slope        : +
Level        : Zero
```

Set the input of CH1:

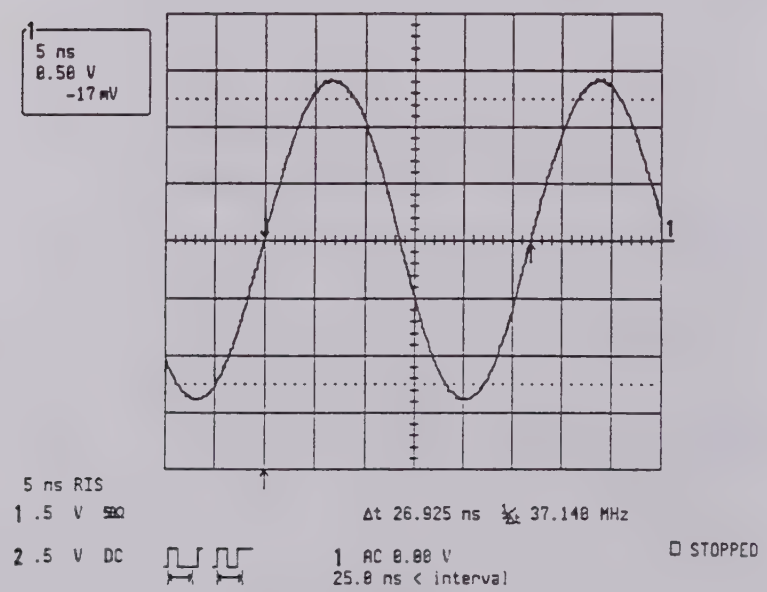
```
Coupl : 50 Ohm
Gain  : .5 V/div
VAR   : Gain 1
Offset: Zero
```

Set time base:

```
Time/div   : 5 nsec/div
Interleaved: ON
```

Apply sine wave signal of 2.8 V p-p at 100 MHz to CH1 Turn to interval Width > and adjust width to 25 nsec.

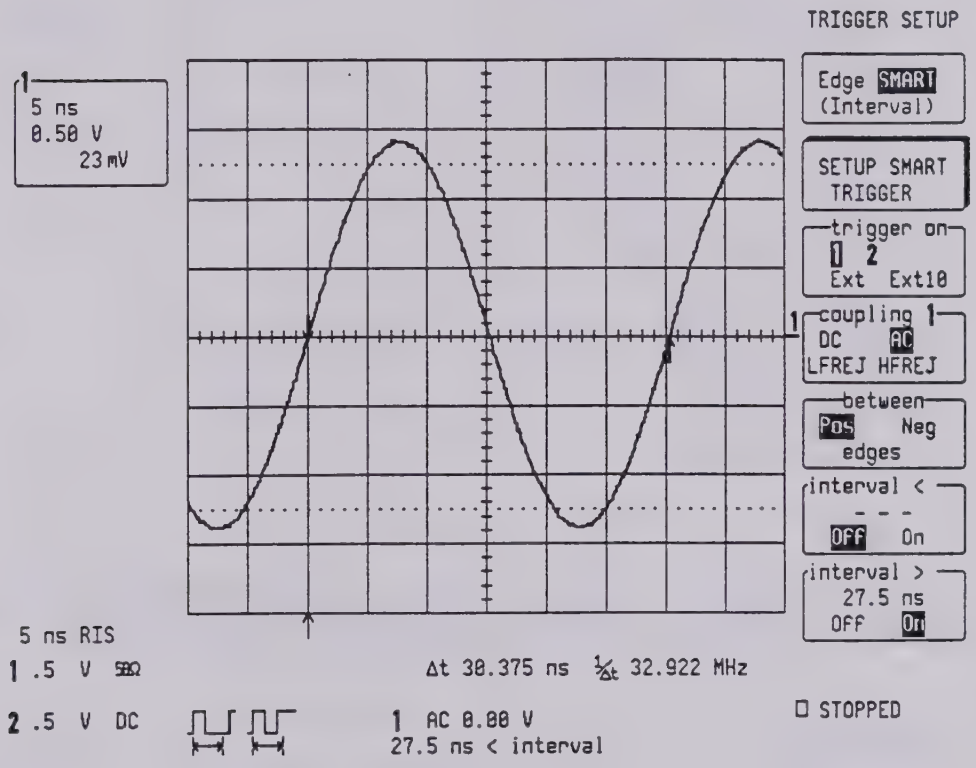
Check:
- 100 MHz: Width > 25 nsec, scope should NOT trigger
- 44 MHz : Width > 25 nsec, scope should NOT trigger
- 37 MHz : Width > 25 nsec, scope should trigger



Set the frequency to 40 MHz and interval width to > 27.5 nsec.

Check:
- 40 MHz: Width > 27.5 nsec, scope should NOT trigger
- 33 MHz: Width > 27.5 nsec, scope should trigger

Repeat the above test for CH2.



1.11 Time Base Accuracy

In order to verify the time base, use a sine wave generator of 1 MHz with a frequency accuracy of better than 10 ppm (for example Marconi 2019A).

The following procedure describes a method to check whether the accuracy of the clock is:

100 MHz ± 20 ppm (± 0.002%)

Set the trigger:

Smart trigger: OFF
Source : CH1
Coupl : DC
Mode : NORM
Slope : +
Delay : 0%
Level : Zero

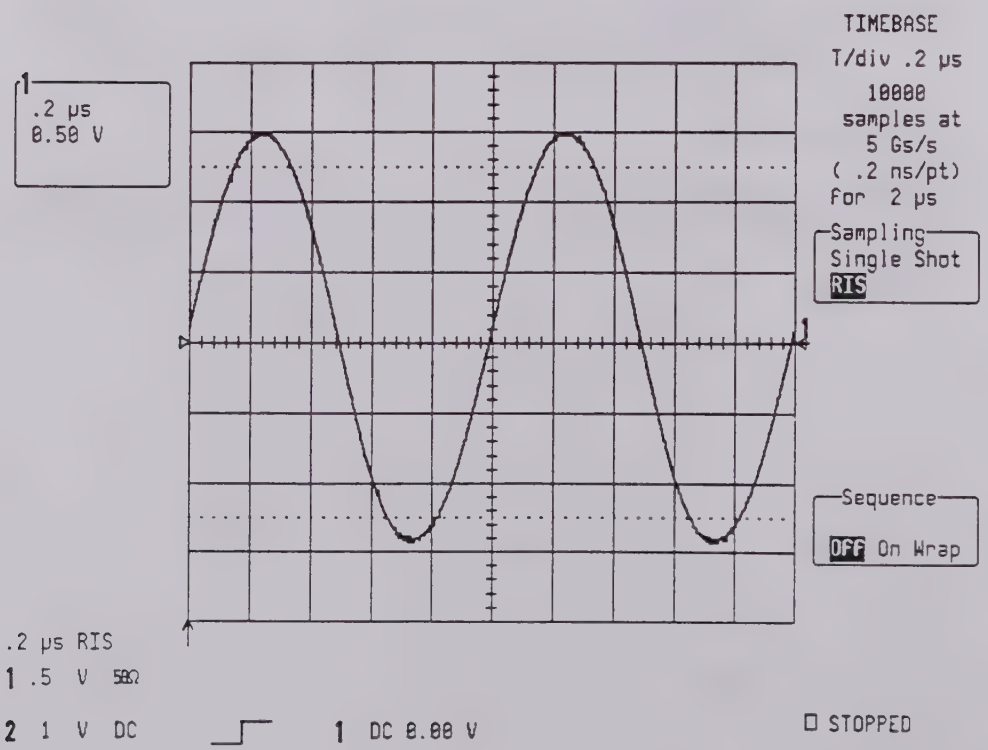
Set the input of CH1:

Coupl : 50 Ohm
Gain : .5 V/div
Var : Gain 1
Offset: Zero

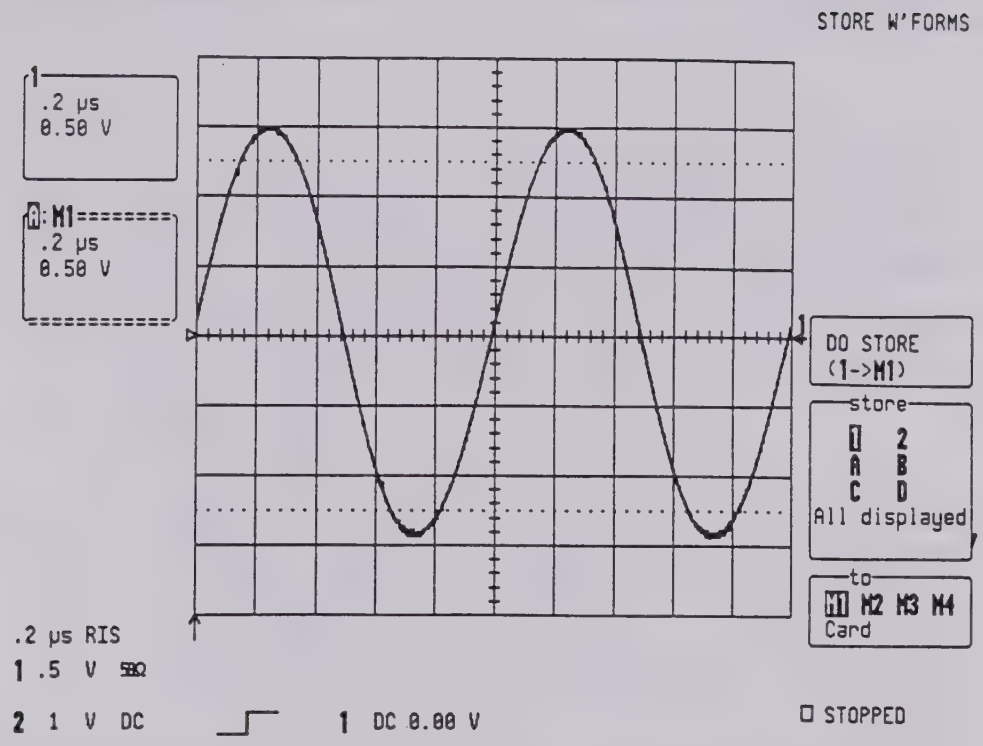
Set the time base:

Time/div: .2 µsec/div
RIS : ON

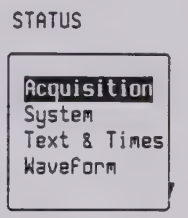
Set the sine wave generator to 1 MHz and apply a signal to CH1. Adjust amplitude to get about a 6 divisions peak to peak display.



Store channel 1 in memory 1.



Set post-trigger delay to 1000.00 µs. This allows the accuracy of the time base clock to be checked 1000 periods after the trigger point.



ACQUISITION STATUS

	1	2
Vertical		
V/div	.5 V	1 V
Probe	x1	x1
Offset	-0 mV	0.01 V
Coupling	DC50Ω	DC1MΩ

Bandwidth Limit OFF

Time base
Time/div .2 µs Time/pnt .2 ns (5 Gs/s)
RIS ON, typically needs 230 triggers for 50 bins
Sequence OFF Pts/div 1000

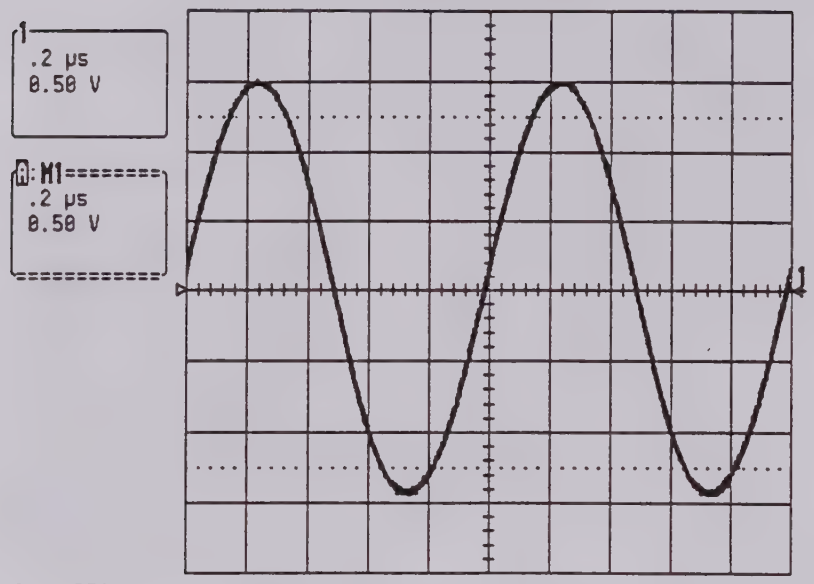
Trigger Edge Mode STOPPED

1 DC 0.00 V

Post-trigger Delay 1000.00 µs

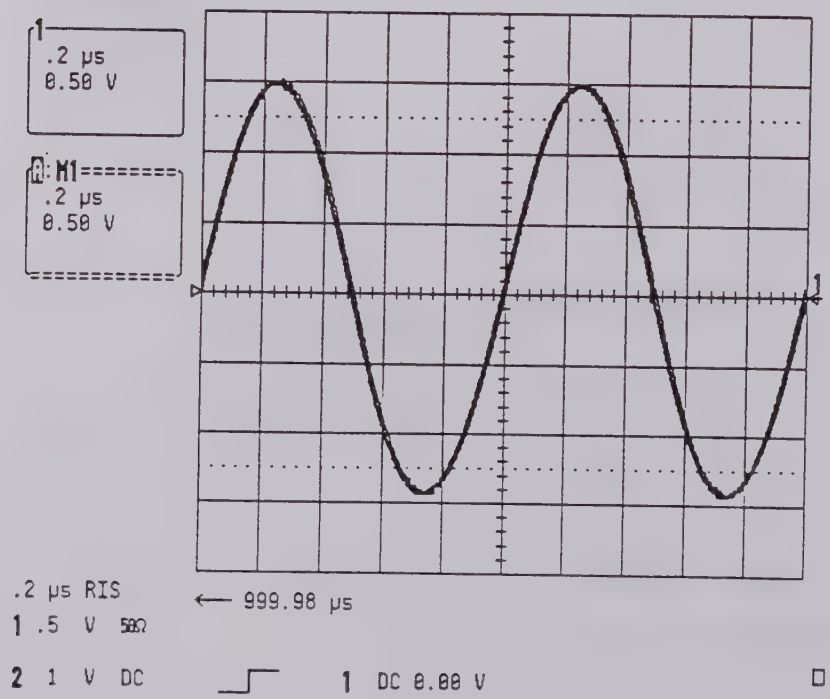
The currently preselected Smart Trigger type is
Interval

Check that the displayed channel 1 trace is aligned with the sine wave from memory 1.



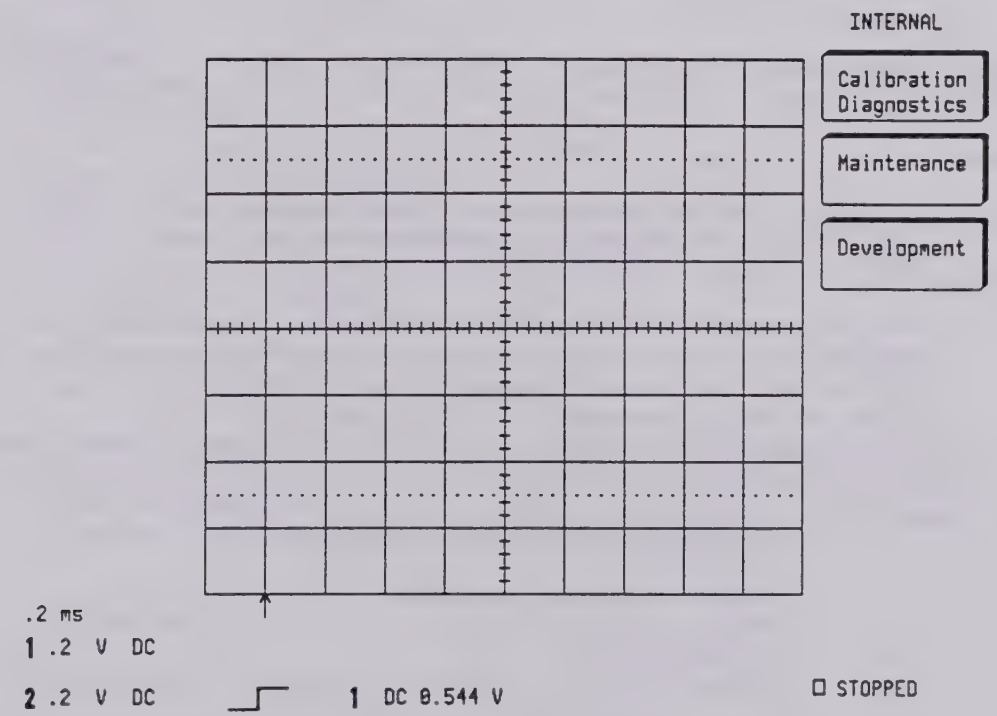
A difference of ± 0.02 µs corresponds to ± 20 ppm.

See figure below.

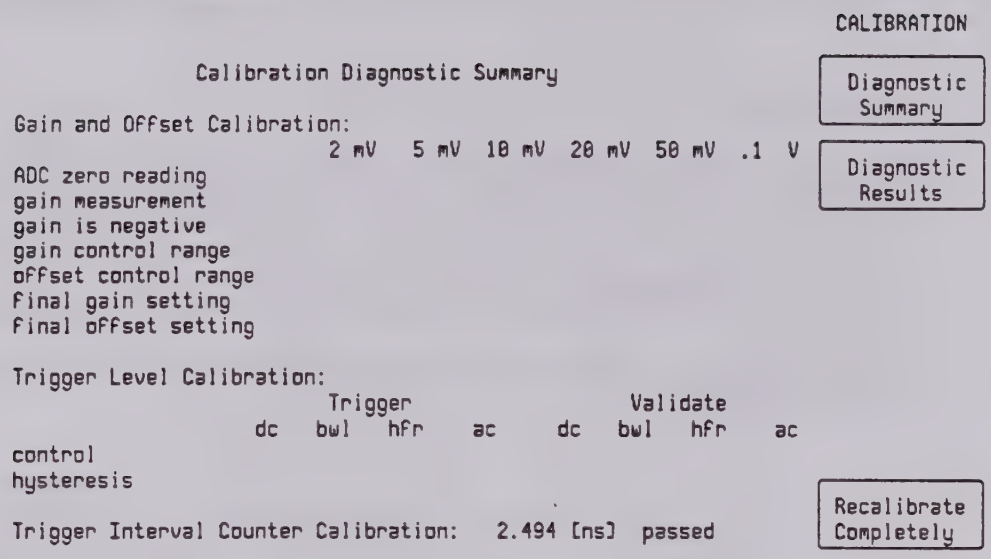


2.1 Introduction

The 9310 internal calibration and diagnostics menu is entered by simultaneously depressing the third and fourth menu push buttons on the right hand side of the CRT and then by depressing the fifth.
To quickly check the performance of the 9310 oscilloscope, select the calibration diagnostics, and press diagnostic summary.
Press the calibrate completely button to do a full recalibration of the front end.
It is advisable to perform this type of check when the scope is in a stable condition.



2.2 Diagnostic Summary



Failures are indicated by channel identifiers. Fields are left
blank if no problem detected or a failure occurred prev
Monitor: rc 5; 1: Δg 393, Δo 0

This is a handy tool to perform a quick but comprehensive internal performance check, without touching the acquisition settings. The failures are indicated by channel identifiers.
If no problem is detected, the fields are left blank.
The gain and offset results displayed for CH1 and CH2 are independent of the following conditions:

- 50 Ohm or 1 MOhm input impedance
- Time base
- Trigger mode and coupling
- BWL on or off
- Variable gain
- Offset

The internal calibration is checked at 1 MOhm, DC and for the six gain settings: 2 mV, 5 mV, 10 mV, 20 mV, 50 mV, 100 mV. The five ranges 0.2 V, 0.5 V, 1 V, 2 V, 5 V are not calibrated.
The 50 Ohm input is not verified by the calibration.

2.3 Gain and Offset Calibration Description

ADC zero reading:	For this test the DAC offset is set to zero. The variable calibration signal is changed until the ADC reads zero.
Gain measurement:	The value of the variable gain is measured.
Gain negative:	An error is displayed if a negative gain is found.
Gain control range:	This test verifies the range of the variable gain.
Offset control range:	The range of the variable offset is checked.
Final gain setting:	The variable gain and fixed gain is changed.The measurement is verified.
Final offset setting:	Not yet implemented.

2.4 Trigger Level Calibration

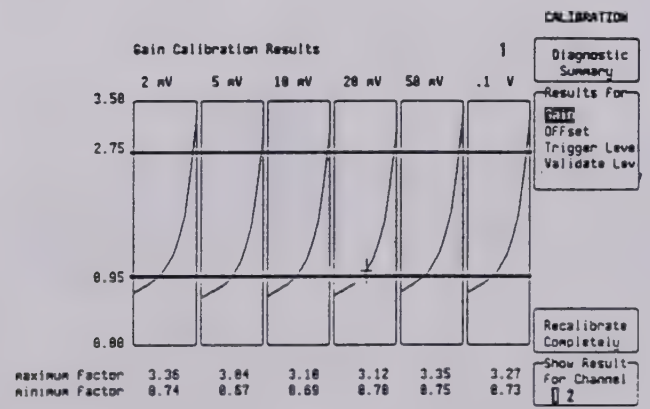
The control of the trigger hysteresis is done in the trigger mode: DC, BWL ON, HFR, AC, for the two trigger sections: trigger level and validate level.
If an error occurred 1, 2 or E is displayed corresponding to channel 1, channel 2 or external trigger.
Trigger level corresponds to the MTR408 in LOC A5002, and validate level corresponds to the MTR408 in LOC A5001.
Trigger interval counter calibration must be passed if no trigger calibration is detected.

2.5 Diagnostic Results

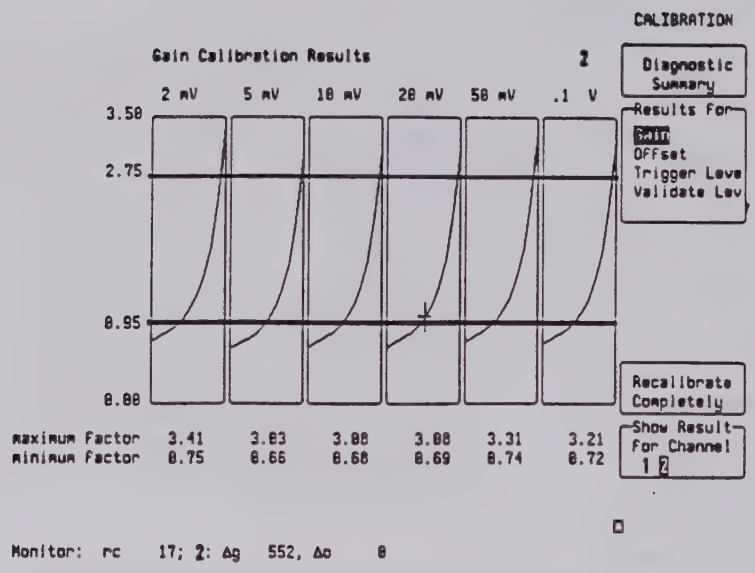
This menu displays the gain curves and offset curves of channel 1 and channel 2. The tests allows the user to check whether the dynamic range of the programmable input amplifiers is sufficient. The trigger level is checked for channel 1, channel 2, and external trigger.

2.6 Gain Curves

Select results for gain, and show result for channel 1.



Monitor: rc 6; 1: Δg 422, Δo -3

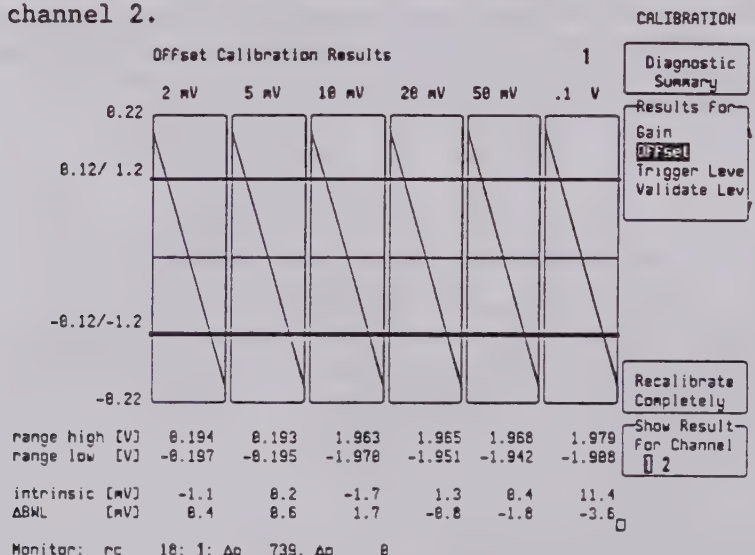


X = DAC range , from -10 V to +7.5 V
Y = Inverse of the gain

Variable gain range, checked by software must be better than 0.95 to at least 2.75 for the six displayed sensitivities. With regard to the illustration, the lower portion of the curve must extend below the 0.95 limit, and the upper portion above the 2.75 limit. The maximum and minimum factor is displayed for each range.

2.7 Offset Curves

Select results for offset show result for either channel 1 or channel 2.



X = Offset DAC range
Y = Offset

The curves should be above the positive limits 0.12 V / 1.2 V and below the negative limits -0.12 V / -1.2 V.

- For the sensitivities: 2 mV/div, 5 mV/div, a 1/10 attenuator is used, the limits are ± 0.12 V.
- For the sensitivities 10 mV, 20 mV, 50 mV, 0.1 V/div, the limits are ± 1.2 V.

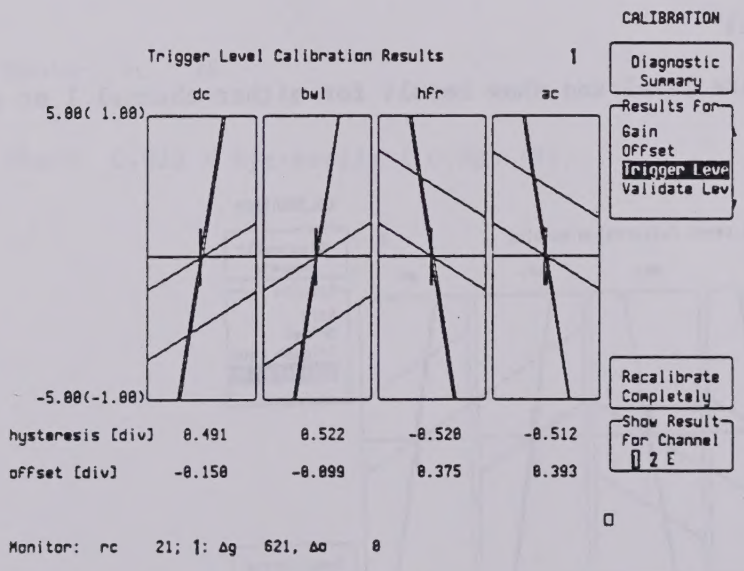
The maximum and minimum offset is ± 1.2 V. The calibration verifies that the DAC can reach this value.
The intrinsic value represents the offset in mV that should be applied to get zero offset to the ADC.
NB: Delta BWL is the difference between BWL on and BWL off.

2.8 Trigger Calibration

For channel 1 and channel 2 the trigger range is ± 5 divisions. This hysteresis value is given in divisions. The positive and negative slope are displayed. The difference between the two slopes represents the trigger hysteresis.
A zoom of the positive or negative hysteresis is displayed, the scale is ± 1 division. For the external trigger the hysteresis is in volt.

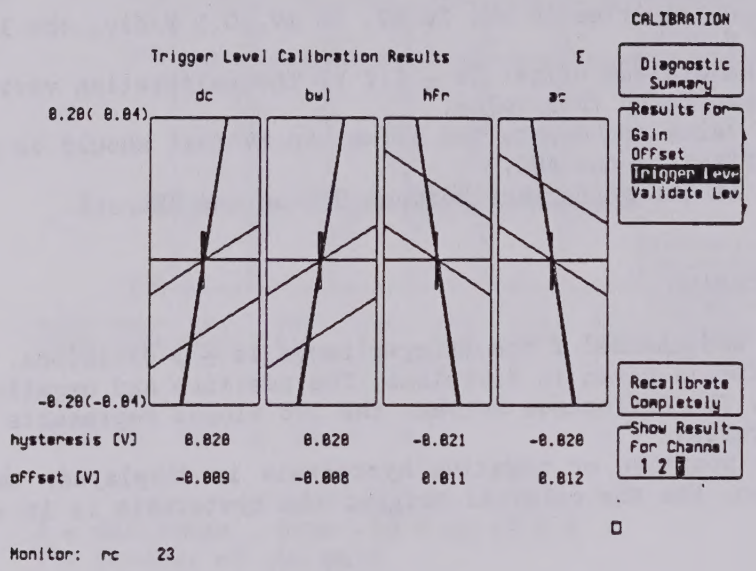
2.9 Trigger Level

Select trigger level and show result for channel 1 or channel 2.



The hysteresis should be 0.5 Div ± 0.1 Div, the offset of the positive slope is also mentioned.
The trigger adjustment is described in the Front end calibration procedure.

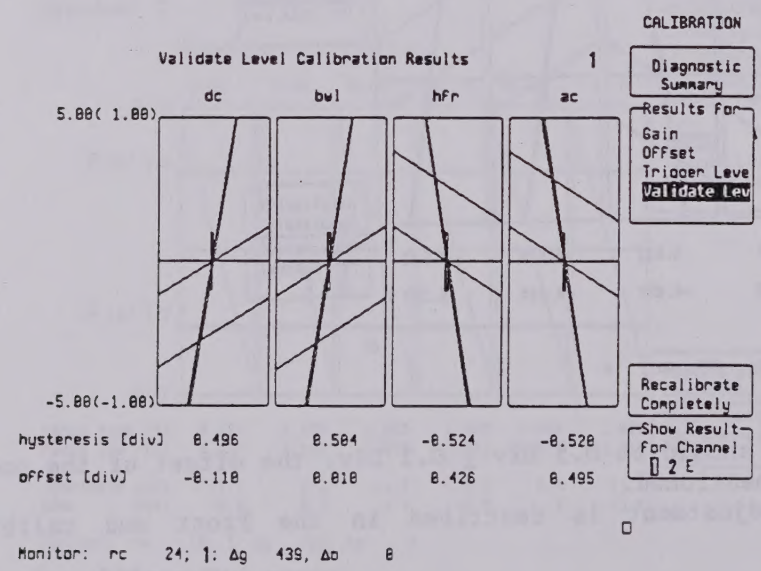
Select show result for external.



The hysteresis in volts should be 0.02 V ± 0.005 V.

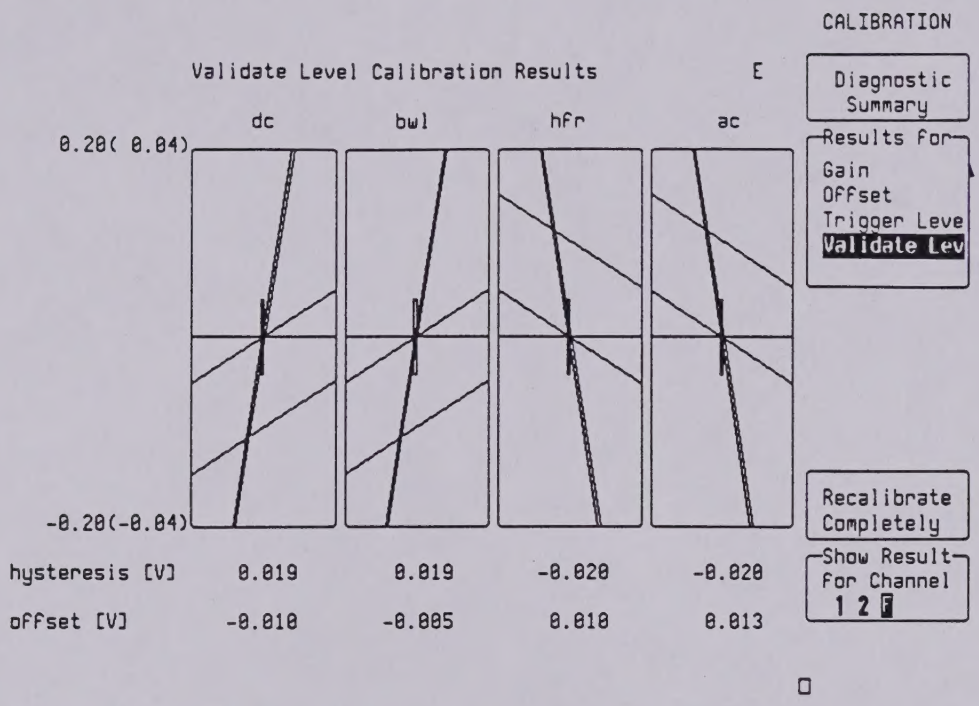
2.10 Validate Level

Select validate level and show result for either channel 1 or channel 2



Check: 0.4 < hysteresis < 0.6 (Div).

Select show result for external.



Check: 0.015 < hysteresis < 0.025 (V).